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Why Micro Printing Is the Future of Large-Area Electronics

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ABSTRACT

In this talk, the advantage of the micro-printing process for large-area electronics. We will review different approaches to device integration, possible functional devices, and the VueReal solutions to solve the challenges in the field.

1 Introduction

Several methods have been tested for transferring microLEDs into display substrates. However, they suffer from low yield, low throughput, expensive solutions, or low-performance products.

These solutions are based on pick and place or laser transfer. For pick-and-place, the complicated process steps reduce the throughput and cause a lower yield. On the other hand, laser transfer leads to higher material costs due to a larger LED pitch, lower throughput, and lower LED yield. Figure 1 shows the steps with the pick-and-place transfer. This method includes several steps (moving to the donor substrate, alignment with the donor substrate, and picking up microLEDs) to pick up microLEDs and several steps (moving to the display substrate, aligning with the display substrate, and bonding microLEDs to display substrate) for placing microLEDs to display substrate. As seen, the process includes several steps with finite yield, leading to lower combined yield. More importantly, by increasing the throughput, the size of transfer heads should increase. As demonstrated in Figure 2, the wafer utilization drops as the size of the transfer head increases. As the transfer head's size increases, most circle shape wafers cannot be transferred. In addition, the larger transfer head means more wafer non-uniformity will be transferred to the display.

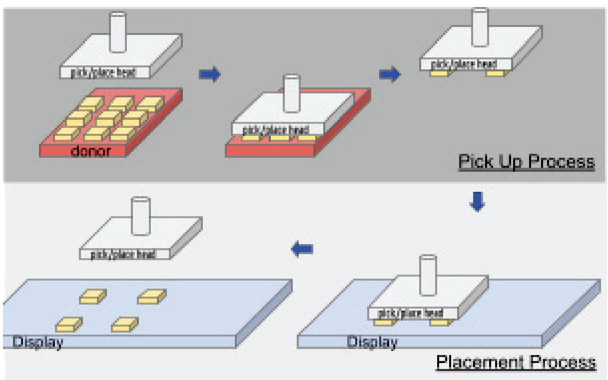

Figure 1: Pick-and-Place transfer.

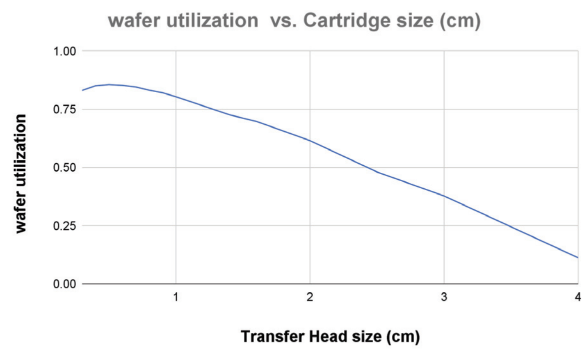

Figure 2: Transfer head size vs wafer utilization efficiency.

The main advantage of pick and place is the tool's simplicity.

Figure 3 highlights the laser transfer setup. Here, the donor substrate is aligned with the display substrate. Next step, the laser beams are applied to the microLEDs selectively and separated from the donor substrate. To increase the throughput, the number of beams needs to increases. Here, the optics can be very cumbersome for high throughput processes. In addition, the transfer can cause rotation, tilting or damage microLEDs during transfer..

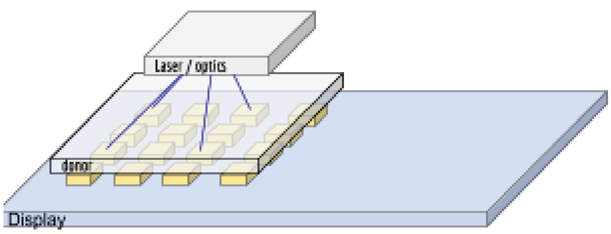

Figure32: Laser transfer.

However, despite complexity and process issues, laser transfer offers high selectivity.

In both processes, the pitch between LEDs or the size affects the transfer significantly. As a result, most of the methods today use wide spaces or large devices.

VueReal has developed a MicroSolid Printing process that enables simple tools and immense selectivity. In addition, itallowss high yields and throughputs and provides a path for small device (and small pitch) printing leading to lower costs.

2 VueReal MicroSolid Printing Process

VueReal MicroSolid printing uses a cartridge to selectively release the microLEDs into the display substrate. In addition, the cartridge has a small led pitch and can print a few micrometres to several 100-micrometre devices.

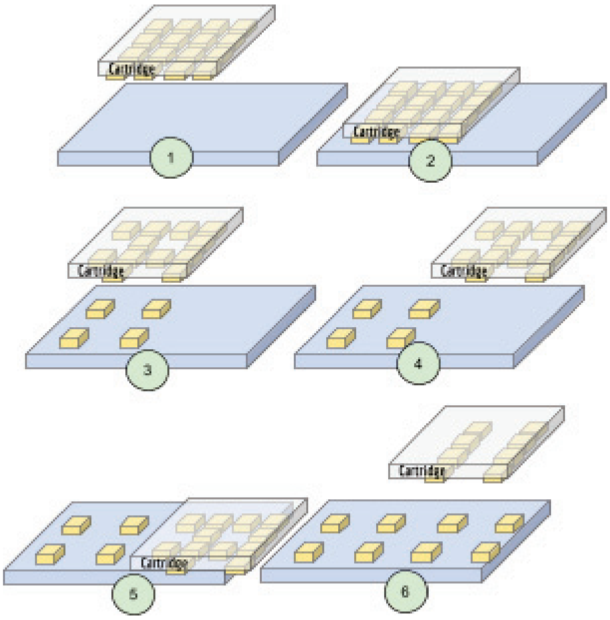

Figure 4: VueReal MicroSolid Printing for two consecutive offset and print steps.

As the cartridge does most of the process, the tool can be straightforward. Furthermore, the method enables binning of cartridges. Figure 5 shows an image of the wafer maps with cartridges. As it can be seen, the wafer non-uniformity and defects can be significant. Here, we use cartridges that have similar performance. In addition, the wafer usage can be very high.

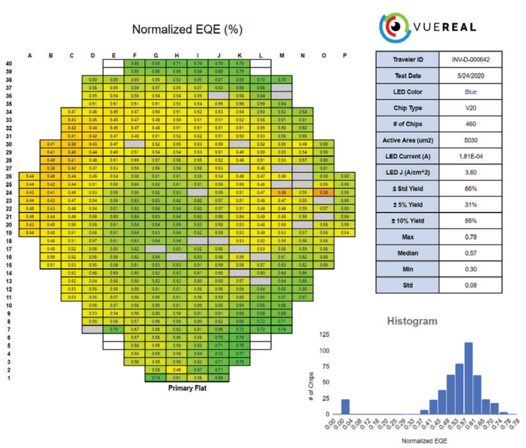

Figure 5: LED wafer Uniformity extracted with cartridge inspection.

To improve the throughput, VueReal uses multiple cartridges during the transfer. The cartridges can be small to avoid defects and non-uniformity. Furthermore, VueReal has developed multi-colour cartridges which allow single printing steps for all three colours at once.

Figure 6: Display samples fabricated with MicroSolid printing.

VueReal has developed a versatile, flexible and sustainable printing process to print micrometre semiconductor/optoelectronic devices into a surface to create functional surfaces such as displays at the yield and throughput required for such products. The VueReal cartridge-based printing process is developed to offer a simple, scalable tool with faster throughput, higher yield, and high uniformity. This solution does not require picking micro led for every transfer and does not require a laser for releasing micro-LEDs into the display substrate. This solution allows the integration of different devices into the substrate to develop different functionalized surfaces. While the current large-area fabrication approach for display offers limited functionality, the combination of microprinting and different fabrication processes removes this barrie

3 VueReal Color Conversion Approach

In addition to using RGB microLEDs and different material sets; for some applications, microLED with QDOTs can be a preferred solution for some applications.

VueReal has developed a solution that enhances the light coupling of small microLEDs (10um) and thin QDOT film (4 um). Blue MicroLED offers the highest performance and can provide wavelengths with higher QDOT absorption efficiency.

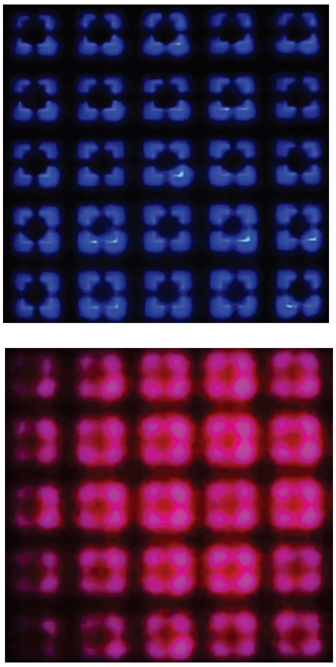

Figure 7: 100um pixels with 10um microLED before and after colour conversion layer.

Figure 7 shows a picture of the pixels before and after the colour conversion description. In addition, the VueReal solution enables using QDOTs for defect compensation. Here, the microLEDs are turned ON, and defects are identified. The results are used to adjust the colour correction patterning. Figure 9 shows the process and developed samples with intentional defects (one defect per 10 pixels. as it can be seen, the flat field results show no visible defects.

This solution can be used on large monolithic TVs with lower cost and higher quality displays than tiled displays. Using VueReal microSolid printing and QD inkjet printing, the TV fabrication throughput can be around 6 minutes for a 75” and 4K resolution. Furthermore, the fabrication cost of this solution can be in the same range as blue OLED with QD. However, the performance of microLED TV will be superior to OLED due to higher brightness and reliability.

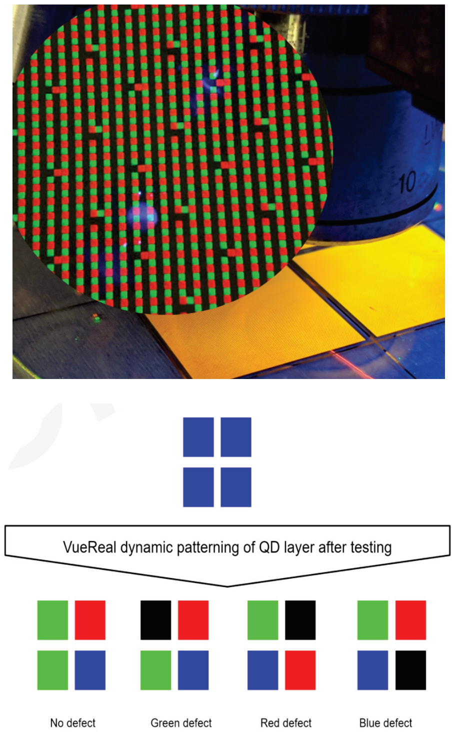

Figure 8: QDOT for colour conversion and defect compensation.

4 VueReal Self-Aligned Displays

Furthermore, for a higher resolution display, the VueReal self-aligned process reduces the tool's need for high alignment accuracy. VueReal’s self-aligned process enables the ultimate displays needed for augmented reality (super high brightness, ultra-high resolution, full colour, low power, and very compact).

Figure 9 shows a display samples that is fabricated with self aligned process. In addition to higher yield transfer process, it enables higher eqe devices.

Figure 9: Display samples made with self-aligned process..

5 Conclusion

VueReal solutions for printing can be used to produce displays for different applications. It can enable low cost displays by using small microLEDs and high wafer utilization.

In addition, this solution uses simple tools and can be scaled to large areas.

For high-resolution displays, the VueReal self-aligned process leads to small full, colour displays for augmented reality.

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